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AN UNDER-FREQUENCY BASED ISLANDING SCHEME OF RAJASTHAN POWER SYSTEM

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ABSTRACT

This paper describes under frequency based islanding scheme of the Rajasthan power system. On the basis of simulation studies, under frequency based islanding scheme have been designed. The islanding power system consists of two generators having total 500 MW generation capacity and 475 MW average island load. Proposed island is connected through 5 numbers 220 KV circuits and 2 numbers of 400/220 KV transformers from the grid. Under frequency based islanding relays are placed at interconnecting points. Further under frequency based load shedding relays are also placed in the island to control the island frequency in the event of generation and load imbalance. On the basis of simulation studies frequency setting of under frequency load shedding relays have been decided so that in the case of mismatch between generation and load in the island proper load shedding may be activated. Simulation results are presented up to 10% overload of Island. Simulation results indicate that proposed island scheme is successful up to 10% overload of Island. Active and reactive power loading on generators are within limits up to 10% overload of Island and Island frequency is stabilized greater than 49 Hz. In all possible mismatch between island generation and load, frequency does not drop up to 47.50 Hz.

KEYWORDS: Auto Load-Shedding, Islanding, Rate of Change of Frequency, Under Frequency Load Shedding

INTRODUCTION

There were two major grid disturbances, one at 02.33 hrs on 30-07-2012 and second at 13.00 hrs on 31-07-2012 in Indian Power System. The first grid disturbance affected mainly Northern Region and the second disturbance resulted in collapse of Northern, Eastern, and North-Eastern regional grids. Such type of disturbance invokes islanding scheme in the power system to avoid complete blackout of power system. This paper presents a simulation study methodology for formation of stable islanded power system under the event of grid disturbance. Auto load shedding scheme is proposed inside the island to control the islanding frequency and over loading of generators inside the island. On the basis of simulations frequency of load shedding relays have been finalized. Simulation studies have been carried out using Mi-Power software which is designed by the M/s PRDC Bangalore. Load shedding by operation of under frequency relays, frequency response of Islanded System, generators active & reactive power output, generators terminal voltage, response of governors & AVRs has been plotted. Simulation studies indicate that with proper setting of UF relays island is successfully formed and stabilized at acceptable frequency with least load shedding under all possible power exchange with the grid.

PROPOSED TECHNIQUE

dF/dT Relay

dF/dT relay operates when the rate of frequency change is above the set point. Relationship between variation in frequency and Load generation mismatch is given by

$$dF/dT = P_A\, f_0 / 2\, G\, H \qquad (1)$$

Where

G= Nominal MVA of machine under consideration

H= Generator Inertia constant in MJ/MVA

f_0= Nominal frequency

P_A= Net accelerating or decelerating Power

For group of generators the inertia constant H is calculated from

$$H = (H_1{*}MVA_1 + H_2{*}\, MVA_2 + \ldots\ldots\,..) / (MVA_1 + MVA2 + \ldots\ldots\ldots\ldots.) \qquad (2)$$

Where 1, 2 etc. refer to individual generators in the group and H is expressed to a MVA base equal to the total MVA capacity of the group.

Design of Load Shedding Scheme

Following need to be defined for design of Automatic Load shedding System

- A model that defines different Generating Machines
- Load Parameters
- Criteria for setting Frequency Relays

Following parameters need to be defined to implement a Load shedding Scheme

Maximum Load that can be disconnected and identify the loads to be disconnected in a sequence. Quantum of load to be disconnected depends on loss of generation or import from the utility.

Starting Frequency of Load shedding scheme should be below the system normal working frequency range and should be coordinated with islanding relay setting.

Minimum Permissible Frequency running below nominal speed at reduced system frequency can cause cumulative damage by excessive vibration. Following table shows typical allowable operation durations at reduced frequencies.

Table 1

Frequency at Full Load	Max. Permissible Time
49.50	Continuously
48.65	90 Minutes
48.50	10 Minutes
48.00	1 Minutes

Operating times at low frequency and full load are cumulative. However, in majority of cases, during transient conditions with load below nominal, reduction of frequency to 93% is permitted without causing damage to turbine or TG auxiliary lubrication and cooling systems.

Setting of Frequency Relays

Settings of frequency relays should be such that final settings satisfy both speed and coordination. It is to be ensured that least amount of load is shed depending on initial over load condition.

Determination of Operating Times

Operating times which indicate final effective load disconnection for successive stages of load shedding shouldbe worked out considering the relay pickup time, intentional delay introduced and the breaker operating time.

SYSTEM DETAILS FOR SIMULATION

In this paper, under frequency based islanding scheme for Suratgarh Thermal Power Plant (STPS) have been designed. Islanding power system consists of 6 numbers of 220 KV substations and 28 numbers of 132 KV substations. There are 6 numbers of 220 KV transmission lines and 15 numbers 132 KV transmission lines in the proposed island. On the basis of availability of 500 MW generation from STPS Unit-1 & 2 and average monthly recorded load at GSS,6 numbers of 220 KV substations and 28 numbers of 132 KV substations are part of proposed STPS island. Single line diagram of proposed Island is placed at Figure-1.

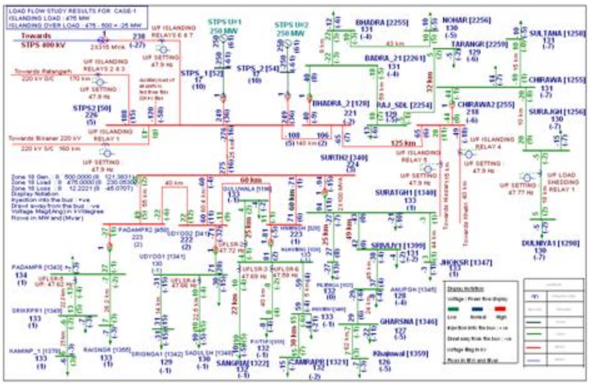

Figure 1: Single Line Diagram of Proposed Island

PROPOSED ISLANDING SCHEME

Island Formation Frequency

Following points are considered for selection of island formation frequency:-

- Normal Grid operating frequency
- Settings of under frequency load shedding relays in the Grid
- Coordination between under frequency protection scheme of generators and islanding frequency
- Maximum possible over load in the Island
- Short time maximum over loading of generator

By consideration of aforesaid points and on the basis of simulation studies, 47.9 Hz frequency without any time delay have been selected for formation of STPS island.

Under Frequency Based Islanding Relays

Proposed Island power system is connected from the Grid through following 220 kV lines and 400/220 kV transformers:-

Table 2

S. No.	Name of Line /Transformer	Active Power Flow (Mw)	Reactive Power Flow (MVAR)
1	220 kVS/C STPS-Bikaner line (Islanding relay-1)	-43	+8
2	220 kV D/C STPS-Ratangarh line (Islanding relay-2 & 3)	-188	+15
3	220 kV S/C Chirawa-Khetri line (Islanding relay-4)	-49	-18
4	220 kV S/C Chirawa-Hissar line (Islanding relay-5)	+28	+11
5	400/220 kV,2x315 MVA Transformers (Islanding relay-6 & 7)	+238	-27

Under frequency based islanding relays with 47.9 Hz tripping frequency without any time delay have been placed on above220 kV lines and 400/220 kV transformers to isolate the STPS power system from rest of the grid for formation of STPS island.

Under Frequency Load Shedding Relays

In islanding mode, system frequency is severely disturbed due to imbalance between generation and load demand resulting in overloading or loss of generation cases. In order to cope with these events, under-frequency load shedding scheme (UFLS) is applied to stabilize the frequency. In view of possibility of maximum 10 %overload in the proposed STPS island, on the basis of simulation studies load shedding relays are placed on following feeders: -

Table 3

Name of Transmission Line	Connected Load	Frequency Setting
132 kVS/C Surajgarh – Dulaniya line (Load shedding relay-1)	5 MW	47.77 Hz
132 kVS/C Hanumangarh- Guluwala line (Load shedding relay-2)	4 MW	47.72 Hz
132 kVS/C Hanumangarh- Sangaria line (Load shedding relay-3)	10 MW	47.69 Hz
132 kVS/C Udyog Vihar – Sadulsahar line (Load shedding relay-4)	10 MW	47.66 Hz
132 kVS/C Padampur-Sri Karanpur Kaminpura line (Load shedding relay-5)	13 MW	47.62 Hz
132 kVS/C Hanumangarh –Rawatsarline (Load shedding relay-6)	8 MW	47.59 Hz
Total Load Shedding	**50 MW**	

The results have shown that proposed load shedding scheme successfully estimates the amount of load to be shed and stabilizes the frequency for these cases. Locations of Islanding relays and load shedding relays are indicated in Single line diagram of proposed Island placed at Figure 1

SIMULATION STUDIES

To validate the proposed islanding scheme for various island loading conditions, simulation studies have been carried out for following 7 cases :-

Table 4

S. No.	Particulars	Island Generation	Island Load	Maximum Available Generation Inside the Island	Approximate Load to be Shedded (Mw)
1	Case-1 (Base Case)	500 MW	475 MW	530 MW	0
2	Case 2	500 MW	500 MW		0
3	Case 3	500 MW	510 MW		10
4	Case 4	500 MW	520 MW		20
5	Case 5	500 MW	530 MW		30
6	Case 6	500 MW	540 MW		40
7	Case 7	500 MW	550 MW		50

Response of under frequency islanding relays, load shedding relays, frequency response of Islanded System, generators active & reactive power output for different cases are plotted.

Simulation Results for Case-1 (5% under Load)

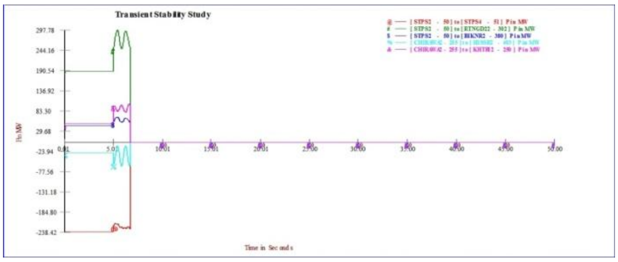

Figure 2: Response of under Frequency Islanding Relays

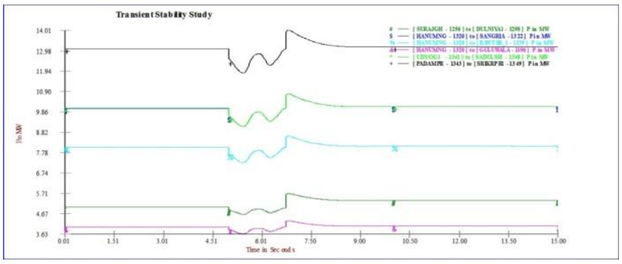

Figure 3: Response of under Frequency Load Shedding Relays

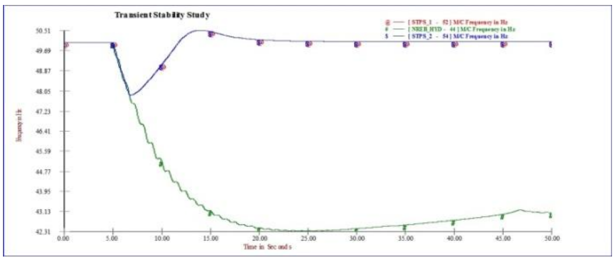

Figure 4: Frequency Response of Islanded Power System

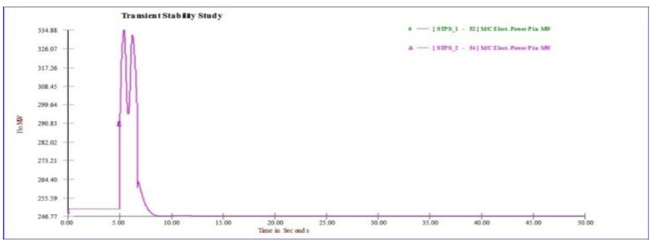

Figure 5: Generators Active Power Loading

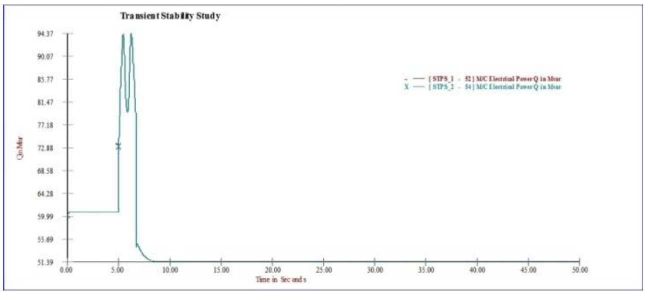

Figure 6: Generators Reactive Power Loading

Simulation Results for Case-2 (0% Over Load)

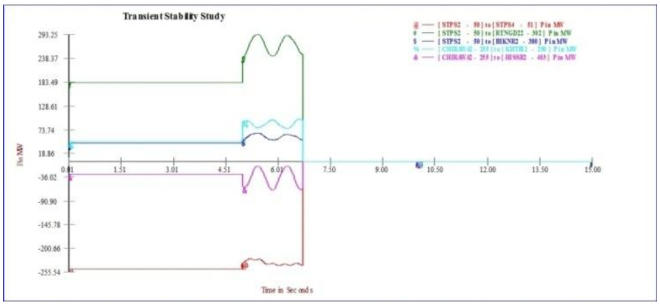

Figure 7: Response of under Frequency Islanding Relays

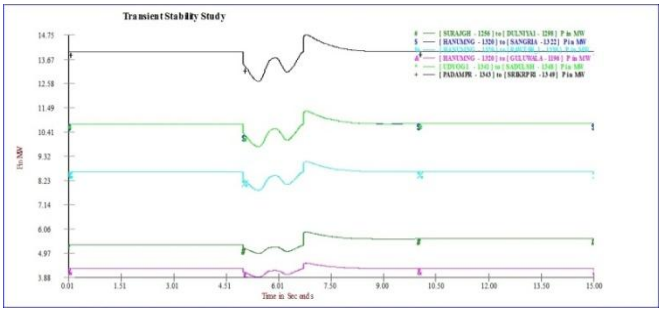

Figure 8: Response of under Frequency Load Shedding Relays

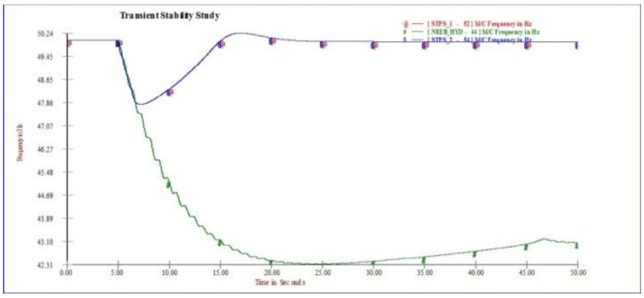

Figure 9: Frequency Response of Islanded Power System

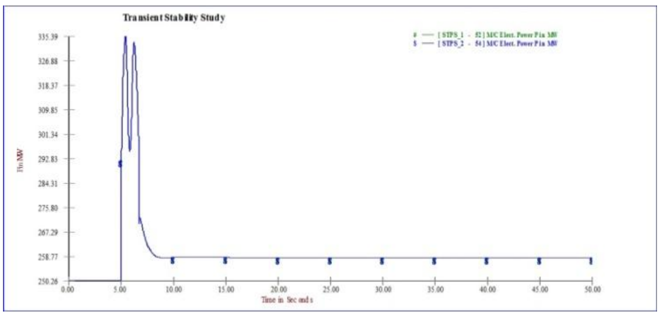

Figure 10: Generators Active Power Loading

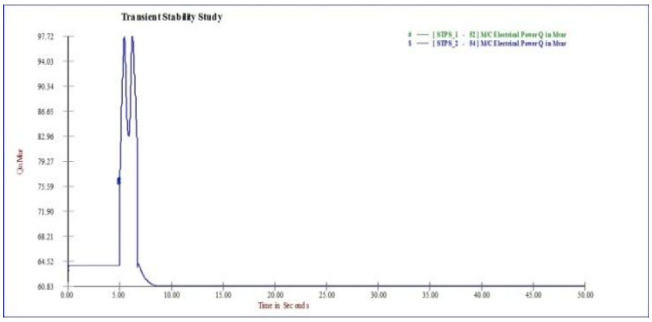

Figure 11: Generators Reactive Power Loading

Simulation Results for Case-3 (2% Overload)

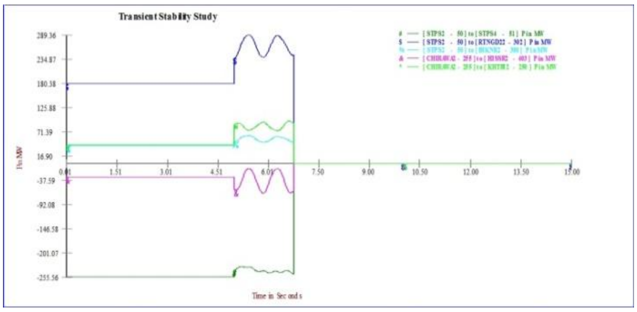

Figure 12: Response of under Frequency Islanding Relays

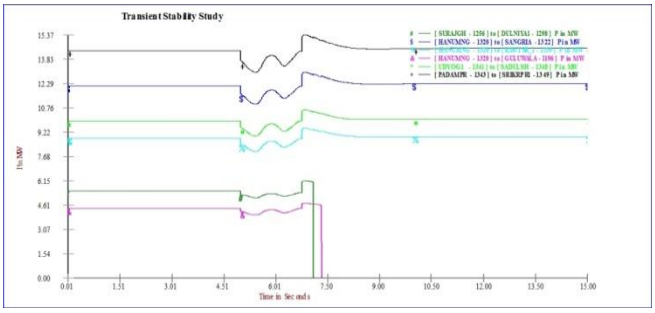

Figure 13: Response of under Frequency Load Shedding Relays

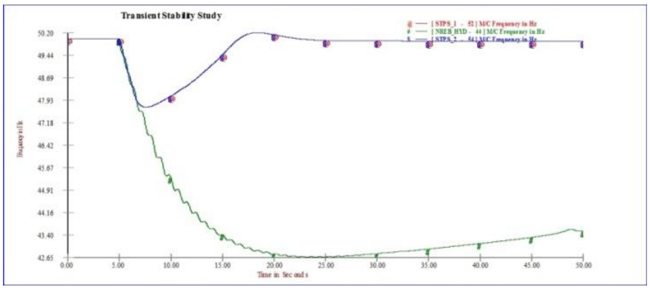

Figure 14: Frequency Response of Islanded Power System

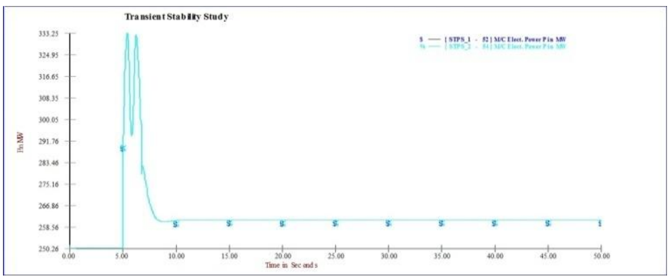

Figure 15: Generators Active Power Loading

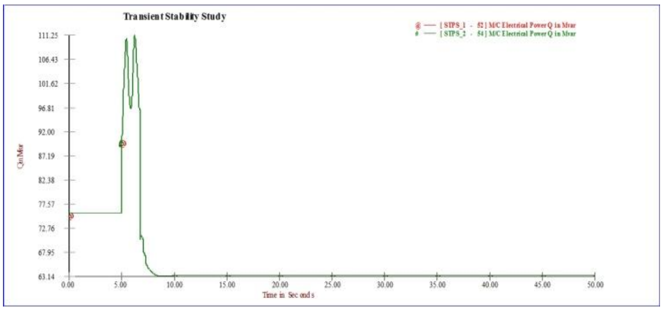

Figure 16: Generators Reactive Power Loading

Simulation Results for Case 4 (4% over load)

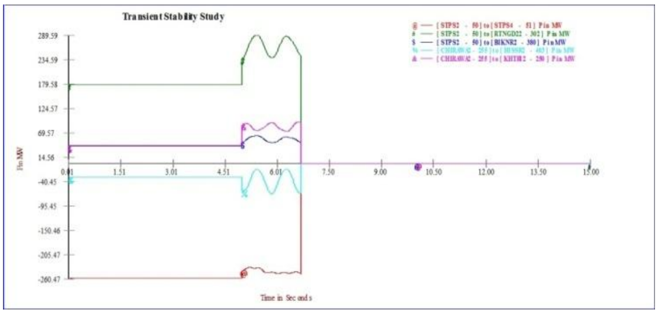

Figure 17: Response of under Frequency Islanding Relays

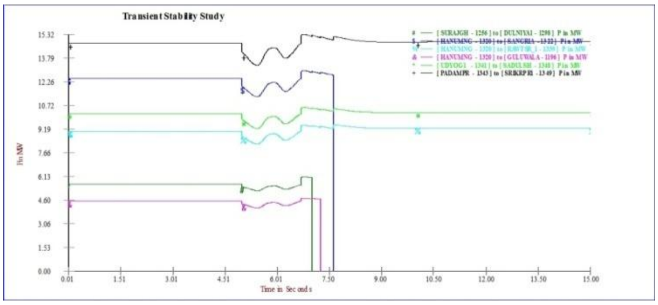

Figure 18: Response of under Frequency Load Shedding Relays

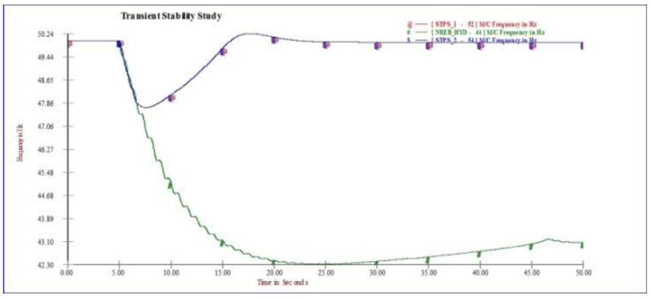

Figure 19: Frequency Response of Islanded Power System

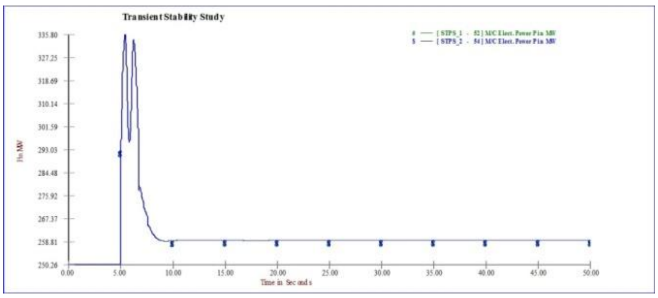

Figure 20: Generators Active Power Loading

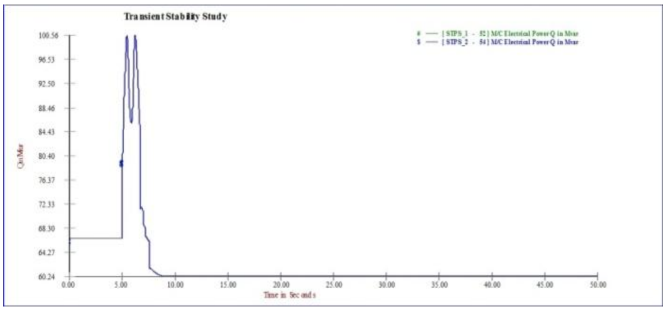

Figure 21: Generators Reactive Power Loading

Simulation Results for Case - 5 (6% over load)

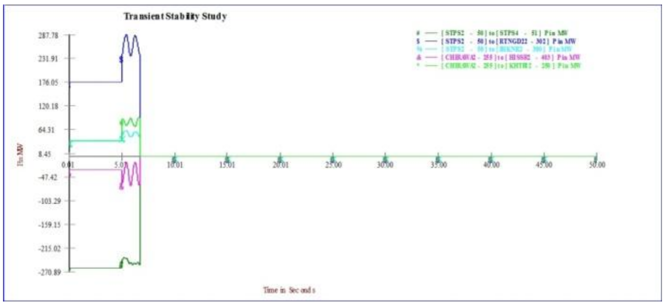

Figure 22: Response of under Frequency Islanding Relays

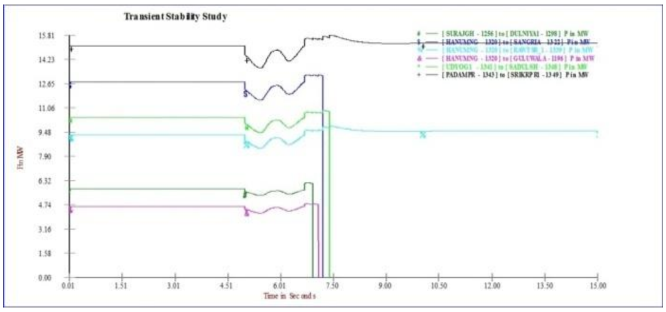

Figure 23: Response of under Frequency Load Shedding Relays

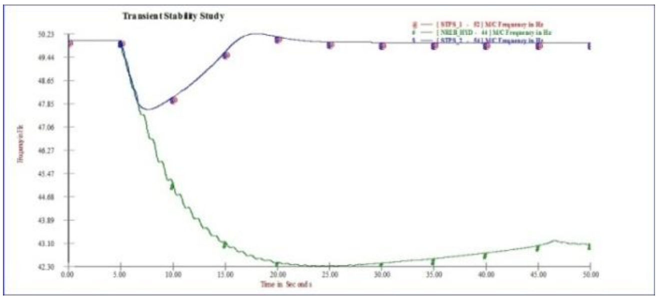

Figure 24: Frequency Response of Islanded Power System

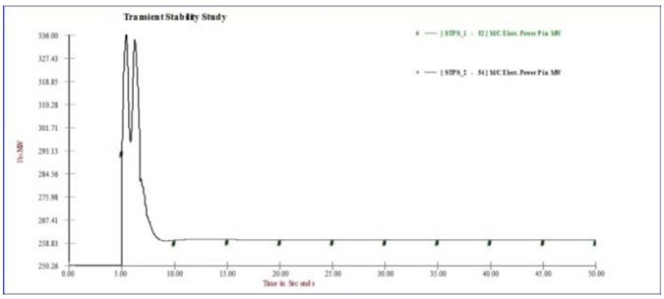

Figure 25: Generators Active Power Loading

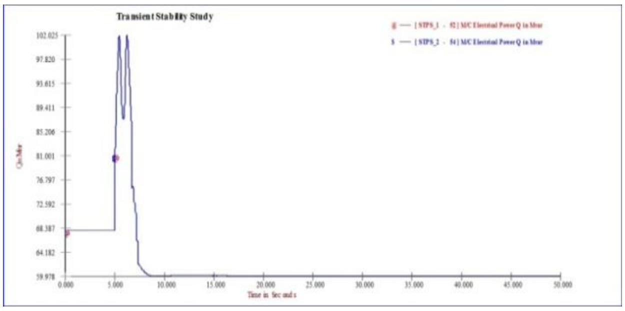

Figure 26: Generators Reactive Power Loading

Simulation Results for Case - 6 (8 % over Load)

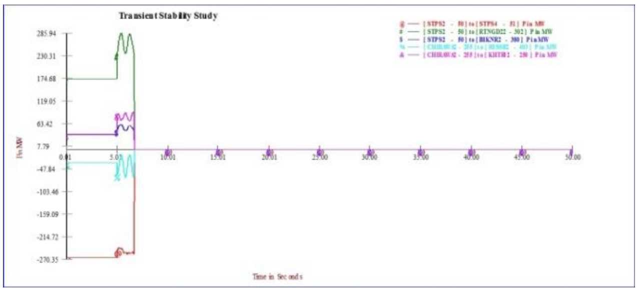

Figure 27: Response of under Frequency Islanding Relays

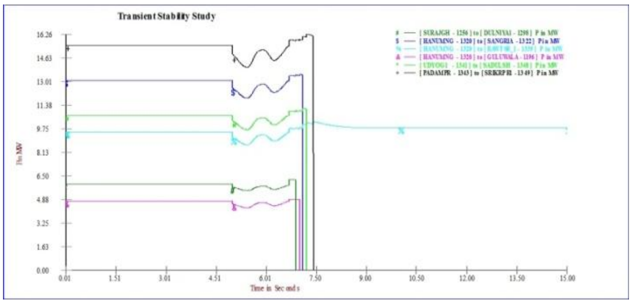

Figure 28: Response of under Frequency Load Shedding Relays

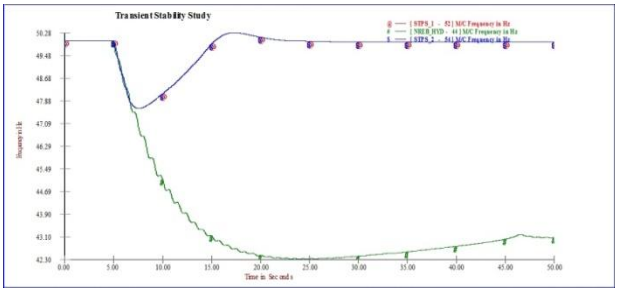

Figure 29: Frequency Response of Islanded Power System

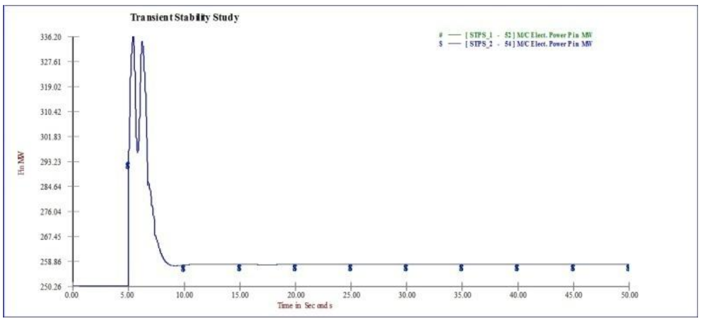

Figure 30: Generators Active Power Loading

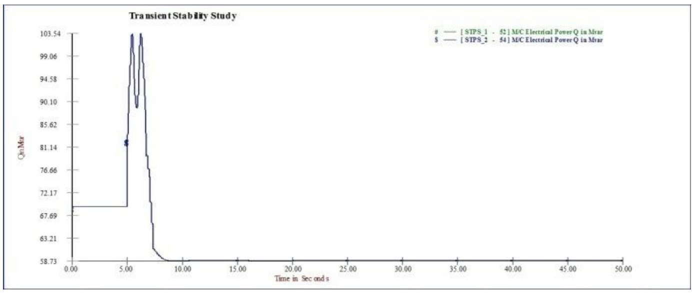

Figure 31: Generators Reactive Power Loading

Simulation Results for Case-7 (10 % over Load)

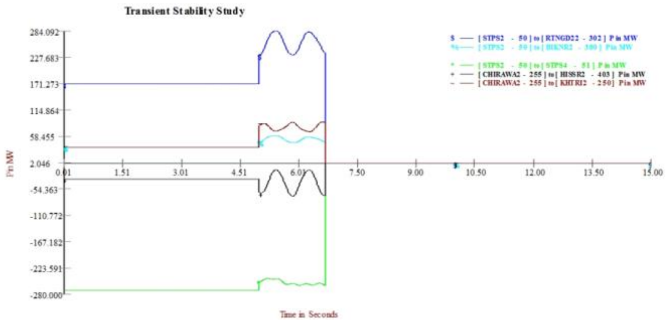

Figure 32: Response of under Frequency Islanding Relays

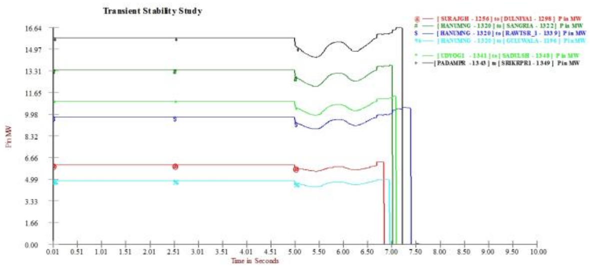

Figure 33: Response of under Frequency Load Shedding Relays

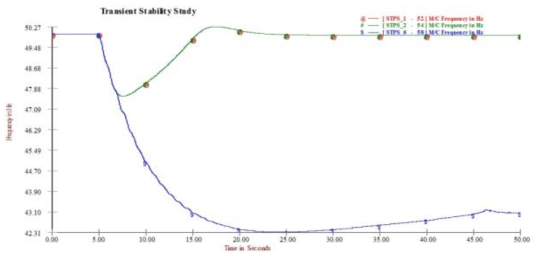

Figure 34: Frequency Response of Islanded Power System

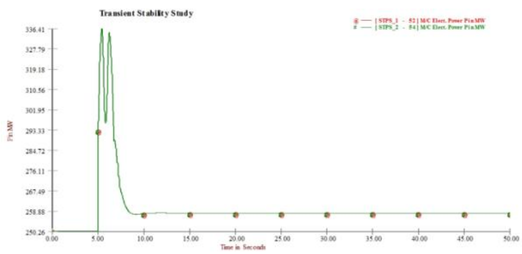

Figure 35: Generators Active Power Loading

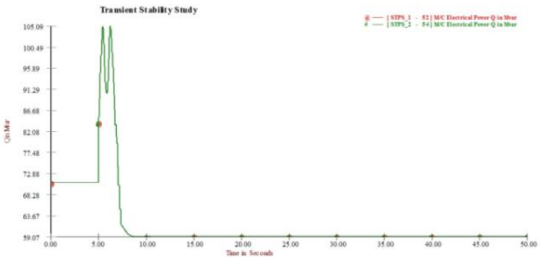

Figure 36: Generators Reactive Power Loading

OBSERVATIONS

- After the occurrence of disturbance in the grid at 5 seconds, frequency starts to fall. When grid frequency becomes 47.9 Hz then due to operation of UFR relays, STPS Island is formed at 47.9Hz.
- In all cases, active and reactive power loading on generators are within limits.
- In all cases stable island frequency is greater than 49 Hz.
- Under frequency load shedding relays are operate properly to control the Islanding frequency.
- In all cases frequency is not drop up to 47.5 Hz.

CONCLUSIONS

This paper describes under frequency based islanding scheme of the Rajasthan power system. On the basis of simulation studies, under frequency based islanding scheme have been designed. Under frequency based load shedding relays are also placed in the island to control the frequency in the event of generation and load imbalance. On the basis of simulation studies frequency setting of under frequency load shedding relays have been decided so that in the case of mismatch between generation and load in the island proper load shedding may be activated. Simulation results indicate that proposed island scheme is successful up to 10% overload of Island. Active and reactive power loading on generators are within limits up to 10% overload of Island and Island frequency is stabilized greater then 49 Hz. In all possible mismatch between island generation and load, frequency does not drop up to 47.50 Hz.

REFERENCES

1. Md. Quamrul Ahsan, Abdul Hasib Chowdhury, S. Shahnawaz Ahmed, Imamul Hassan Bhuyan, Mohammad Ariful Haque, and Hamidur Rahman ," Technique to Develop Auto Load Shedding and Islanding Scheme to Prevent Power System Blackout" ,IEEE Transation on Power System, VOL. 27, No. 1, February 2012
2. B. Delfino, S. Massucco, A. Morini, P. Scalera, and F. Silvestro, "Implementation and comparison of different under frequency load-shedding schemes," in Proc. IEEE Power Eng. Soc. Summer Meeting, Jul.15–19, 2001, vol. 1, pp. 307–312.
3. D. W. Smaha, C. R. Rowland, and J. W. Pope, "Coordination of loadconservation with turbine-generator under frequency protection," IEEETrans. Power App. Syst., vol. PAS-99, pp. 1137–1145, May/Jun. 1980.
4. W. A. Elmore, Protective Relaying Theory and Applications.NewYork: Marcel Dekker, 1994.
5. H. You, V. Vittal, and Z. Yang, "Self-healing in power systems: An approach using islanding and rate of frequency decline-based load shedding," IEEE Trans. Power Syst., vol. 18, no. 1, pp. 174–181, Feb. 2003.
6. P. Kundur, Power System Stability and Control. New York:McGrawHill, 1994.

7. S. S. Ahmed, N. C. Sarker, A. B. Khairuddin, M. R. B. A. Ghani, and H. Ahmad, “A scheme for controlled islanding to prevent subsequent blackout,” IEEE Trans. Power Syst., vol. 18, no. 1, pp. 136–143, Feb.2003.

8. M. V. Venkatasubramanian, M. Kezunovic, and V. Vittal, “Detection, prevention and mitigation of cascading events,” Power Systems Engineering Research Center publication no. 08-18, Sep. 2008.

9. N. Grudinin and I. Roytelman, “Heading off emergencies in large electric grids,” IEEE Spectr., vol. 34, pp. 43–47, Apr. 1997.

10. M. Thaden, “Analysis of a major load island outage on the Potomac electric power company system” IEEE Trans. Power Syst., vol. 14, no.1, pp. 306–311, Feb. 1999.

11. Y. Liu and Y. Liu, “Aspects on power system islanding for preventing widespread blackout,” in Proc. IEEE Int. Conf. Networking, Sensing and Control, Ft. Lauderdale, FL, Apr. 23–25, 2006, pp. 1090–1095.

AUTHOR’S DETAILS

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- Mr. Sarfaraz Nawazhas received his B.E. degree from University of Rajasthan and M. Tech. degree from MNIT, Jaipur. His research interests include power systems and power electronics. He is currently Reader in the Electrical Engg. Dept., Swami Keshvan and Institute of Technology, Management and Gramothan (SKIT), Jaipur, Rajasthan.